

PAPER • OPEN ACCESS

## Investigating groundwater pollution at an open dumpsite using 2D geoelectrical resistivity imaging and vertical electrical sounding

To cite this article: K. M. Bakare *et al* 2019 *J. Phys.: Conf. Ser.* **1299** 012077

View the [article online](#) for updates and enhancements.



**IOP | ebooks™**

Bringing together innovative digital publishing with leading authors from the global scientific community.

Start exploring the collection—download the first chapter of every title for free.

# Investigating groundwater pollution at an open dumpsite using 2D geoelectrical resistivity imaging and vertical electrical sounding

**Bakare, K. M., Aizebeokhai, A. P., Oyeyemi K. D.**

Department of Physics, College of Science and Technology, Covenant University, Ota, Ogun State, Nigeria.

bakarekehindemobolaji@yahoo.com

**Abstract.** Geoelectrical resistivity survey has been conducted within the Kurata dump site in Ota, south-western Nigeria. This present study focuses on the use of 2D resistivity imaging and Vertical Electrical Sounding to delineate conductive leachate point and degree of movement within the subsurface for conceivable groundwater pollution. The 2D resistivity survey was carried out using the ABEM Terrameter (SAS 1000/4000) System with multiple-gradient array electrode configuration. The Vertical Electrical Sounding was conducted using the schlumberger electrode configuration. One 2-D imaging profile of length 100m and one Vertical Electrical Sounding of length 200m were acquired on the established traverse. The resistivity data was inverted utilizing RES2DINV and WinResist to obtain the inverse model resistivity distribution. The 2D inverse resistivity models of the subsurface showed that the study site has a multi-layered aquifer system, four geoelectrical layers were inferred from the resistivity imaging and they are lateritic clay, clayey sand, sandy clay and coarse sand units. There is one aquifer system about 13 m which is highly polluted. The unpolluted aquifer system is localized around 19 m with inverted resistivity range  $498\Omega\text{m} - 685\Omega\text{m}$  in the traverse. Also there might be conceivable sullyng of deep groundwater system in the long term if appropriate moderation procedures are not thought about at the area.

Keywords: Dumpsite, Electrical Resistivity, Groundwater Contamination, Leachate, Pollution Depth

## 1. Introduction

The existence of life depends importantly on water and as the population rises, the call for clean and reliable water increases. Perhaps the pollution of groundwater sources by means of leachate from landfills have been for a long time as documented by [1-2] they looked into landfill practices and considered it as the filling of depressions to dispose solid waste. These solid wastes are dumped into uninhibited sites of excavations, valleys, quarries or probably within urban settlements, commercial and even residential, which are collected, processed and reused in a safe way, to reduce cost by technological or industrial companies.).

Landfill practices are considered as ways to manage the disposal of waste and this is far from the expected goal in many developing countries [3]: When considering a state-of-the-art landfill system, several parameters are considered. These include the careful selection of the location and to ensure that it is constructed and also maintained through the use of adequate engineering methods, this is to



ensure that the risk to man and animals, pollution of the soil, water and air are greatly minimized. During the land filling process, wastes are placed in a mound or lined pit using very appropriate use of landfill gas control and leachate [1]. In developing countries, landfill is usually not deeper than 50cm, and is therefore considered as unlined shallow hollow.[4] considers this as dumps because solid wastes are received in an uncontrolled way, therefore it is put in any available place which would have had some economic benefits to the country, but instead it attracts animals, waste pickers and insects. They also emit harmful and unfriendly smoke from burning. It has also been confirmed by researchers, that protected or lined landfills are still potent to groundwater contamination [5].

Indiscriminate disposal of industrial and domestic garbage has been recognized as some of the medium through which heavy metals are delivered into the soil and a problem that maintains to grow with human development and no approach to this point is absolutely secure [6]. The non-stop accumulation of wastes, terrible monitoring of their degree and lack of remedial solution unavoidably makes the build-up of heavy metals to cause environmental pollution, particularly in developing countries. [7]. Developing countries are expected to upgrade their landfill systems to totally eliminate the issues caused by poor landfill practice systems [4]. To do this, careful selection of the location is important, experts that handle the engineering of these landfills must ensure that pollutions and risk to human and animals are greatly reduced [8].

The aim of this research work is:

- to determine the level of contamination of leachate within the subsurface;
- to locate seepage area and groundwater pathway;
- to access the extent of leachate infiltration in the dumpsite area.

## 2. Methodology

### 2.1. Site description

The area is situated within Ota, behind the High Court in Ado Odo-Ota local government of Ogun State, Southwestern Nigeria. Which lies between Latitudes  $7^{\circ} 56' N$  to  $7^{\circ} 59' N$  and Longitudes  $4^{\circ} 46' E$  to  $4^{\circ} 59' E$  with area coverage of  $872 km^2$ . The Local Government Area is the second largest in Ogun state and it is surrounded by other towns such as Agbara, Igbesa, Owode, Ado-Odo/Ota . It has the largest industrial area and the highest number of industries in the state, is a well-planned urban center; the streets and roads provide easy access for mapping.

Ota is in Ogun state situated within the eastern part of the Dahomey Basin, southwestern Nigeria (Fig. 1). Ota falls on the eastern part of Dahomey Basin which is a mix of inland/seaside that extends from south-eastern Ghana through Togo and the Republic of Benin to southwestern Nigeria. It is isolated from the Niger Delta by the Benin line to the Okitipupa Ridge. Its stratigraphy has been grouped into Abeokuta, Ewekoro, Akinbo, Oshosun, Ilaro and Benin Formation. [10]. The Abeokuta Group is made up of Ise, Afowo and Araromi formations [11-13].

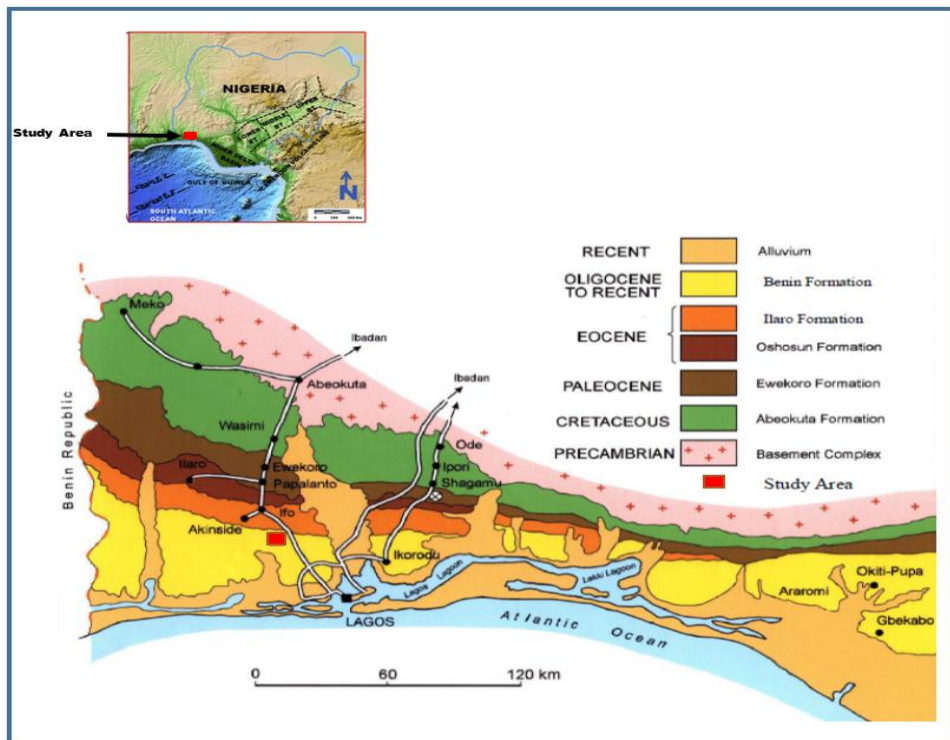


Fig. 1: Geological map of the Nigerian part of the Dahomey basin with an inset map of Nigeria showing the location of study (modified after [14]).

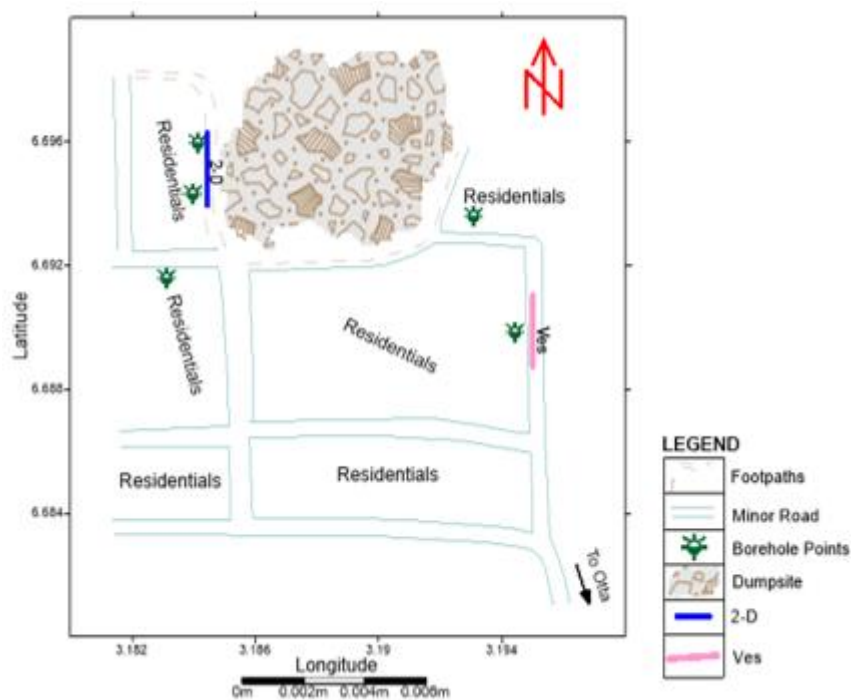


Fig 2: Base map of the study area.

## 2.2. Electrical Resistivity Tomography (ERT)

Electrical resistivity imaging is a sufficient non-intrusive technique to solve problems related to groundwater exploration and environmental contamination [15-30]. Two-dimensional ERT investigations were conducted using an ABEM Terameter (SAS 1000/4000 series) along the survey traverse. The ERT lines, NW-SE directed have a length of 100m and were acquired using a multiple-gradient array with minimum spacing of 5.0m. A total number of 124 data points (apparent resistivity) were acquired using a cycle of four stacks for each quadrupole. The observed apparent resistivity data were processed and inverted using RES2DINV code, employing a least squares inversion modelling technique with regularization technique [15].

## 2.3 Vertical Electrical Sounding (VES)

This technique was used to determine the variation in resistivity values with respect to depth. The schlumberger array was used in the survey. The midpoint of the configuration was kept fixed while the distance between the current electrodes progressively increased. It was conducted along the traverse with electrode spacing  $\frac{AB}{2}$  of 100m. Which was interpreted using computer assisted 1-D forward modelling with WinResist Software which reduced the interpretation error to an acceptable value

## 3. Results

### 3.1. 2D Electrical Resistivity imaging

The interpretation of the survey traverse of the dumpsite shows about four geoelectrical units comprising lateritic clay, clayey sand, sandy clay and coarse sand. The results also present possible leachates infiltrations from the dumpsite into the deeper subsurface aquifer (Figs 3). The inverse model resistivity in the traverse (Fig 3) reveals the percolations of the leachates with very low resistivity values from the near surface downwards to about 13m. The study site has a multi-layered aquifer system; there is one aquifer system about 40-60m and 65-80m which is highly polluted. The unpolluted aquifer system is localized around 19 m with inverted resistivity range 498Ωm – 685Ωm.

### 3.2 Geoelectric Resistivity

Geoelectric section for the vertical electrical sounding which comprises of the sequence geoelectric layer, thickness and resistivity value. The section displays five layers which include the topsoil which has resistivity value and thickness of 93.1Ω and 1.2m respectively which indicate clay layer. The second layer has resistivity of 344Ω and thickness of about 4.7m. The third layer shows a sharp contrast in the resistivity value of about 15.7Ω and thickness of 2.7m which indicate area of high contamination at a depth of 8.4m.

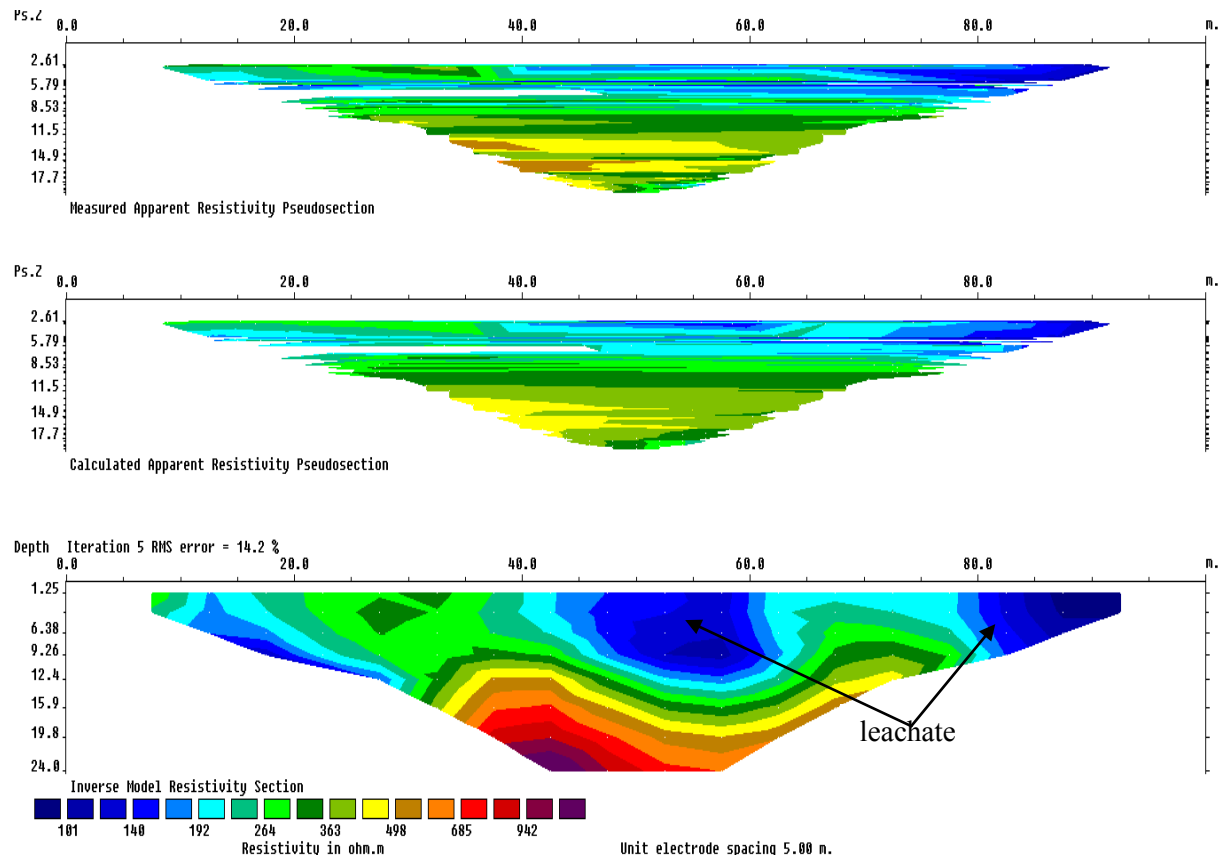


Fig 3: Inverse resistivity model of the ERT line

Table 1: VES interpretation result.

No	Resistivity ( $\Omega$ )	Thickness(m)	Depth(m)
1	93.1	1.2	1.2
2	344.2	4.7	5.9
3	15.7	2.6	8.4
4	138.4	26.4	33.1
5	811.6	-	-

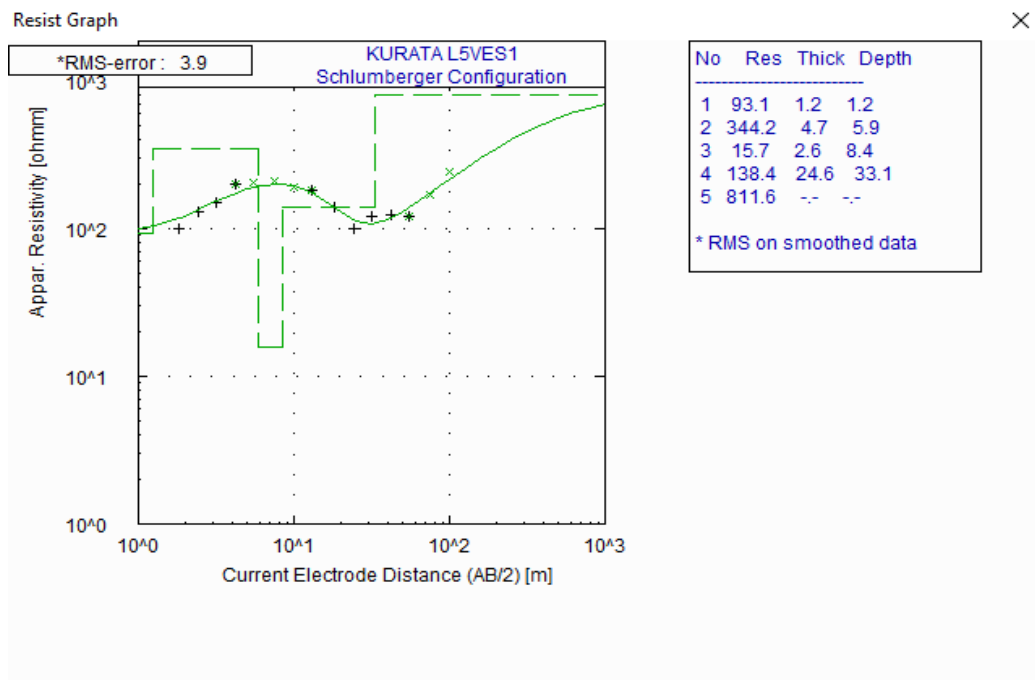


Fig 4: computer iterated curve VES

#### 4. Discussion

The result of the 2D resistivity survey show that the top soil is delineated at shallow depth through zones of low resistivity value suggests the presence of conductive fluid or rock kind. The low resistivity value might have been associated to clayey rock in the topsoil. It shows the infiltration and migration of leachate plumes from a location to another within the dumpsite. The electrical resistivity imaging has the advantage of showing two dimensional evolutions of leachate plumes. The 2D electrical imaging shows the inverse model of resistivity of the subsurface and various lithology with depth. The migration of leachate plumes at kurata dumpsite was monitored in the form of low resistivity zones, these leachates occurred as continuous plumes. The result of the resistivity model shows the usefulness of 2D resistivity imaging method in locating the point of leachate movement within the area. Also, the vertical electrical sounding shows the variation of the resistivity with depth to bedrock which indicates the top layer to be clay with low resistivity of about 93.1Ω with thickness of 1.2m. ERT is a robust, cost effective and non-destructive geophysical technique that can be conducted using several arrays such as Wenner, Wenner-Schlumberger and Dipole-Dipole array configurations for better vertical and lateral subsurface resolutions without compromising their depth of investigation (DOI). This technique produces two dimensional subsurface imaging to predict and characterize the subsoil materials, which will serve as a good information provider to potential borehole investigation in the study area.

#### 5. Conclusion

2D electrical resistivity imaging and Vertical Electrical Sounding survey has been conducted on the Kurata dump site in Ota, southwestern Nigeria. The survey produced the two dimensional electrical resistivity tomography of the subsurface. Four geoelectrical layers were inferred from the resistivity imaging and they include lateritic clay, clayey sand, sandy clay and coarse sand units. The results also revealed the extent of leachate infiltrations into the deeper subsurface contaminating the multi-layered aquifer system in the area.

## 6. Acknowledgement

The authors would like to acknowledge the management of Covenant University through the Centre for Innovation, Research and Discovery (CUCRID) for their support.

## References

- [1] Ganiyu, S. A., Badmus, B. S., Oladunjoye, M. A., Aizebeokhai, A. P., and Olurin, O. T. (2015). Delineation of Leachate Plume Migration Using Electrical Resistivity Imaging on Lapite Dumpsite in Ibadan , Southwestern Nigeria. *Geosciences*, **5**(2): 70–80. <https://doi.org/10.5923/j.geo.20150502.03>
- [2] Pawlowska, T. E., Chaney, R. L., Chin, M., and Charvat, I. (2000). Effects of metal phytoextraction practices on the indigenous community of arbuscular mycorrhizal fungi at a metal-contaminated landfill. *Applied and Environmental Microbiology*, **66**(6): 2526–2530. <https://doi.org/10.1128/AEM.66.6.2526-2530.2000>
- [3] Oyeyemi, K. D., Aizebeokhai, A. P., and Attat, O. F. (2018). Evaluation of groundwater pollution near municipal solid waste landfill site using ERI technique: A case study in Southwestern Nigeria. *Nature Environment and Pollution Technology*, **17**(2): 453–458.
- [4] Gurrero, L. A., Maas, G., and Hogland, W. (2013). Solid waste management challenges for cities in developing countries. *Waste Management*, **33**(1): 220–232. <https://doi.org/https://doi.org/10.1016/j.wasman.2012.09.008>
- [5] Seo, D. J., Kim, Y. J., Ham, S. Y., and Lee, D. H. (2007). Characterization of dissolved organic matter in leachate discharged from final disposal sites which contained municipal solid waste incineration residues. *Journal of Hazardous Materials*, **148**(3): 679–692. <https://doi.org/10.1016/j.jhazmat.2007.03.027>
- [6] Olowookere, B. T., Oyibo, O., and Oyerinde, G. T. (2018). Heavy Metals Concentration in Dumpsites at Gwagwalada, Abuja: Implications on Sustainable Environmental Management. *Greener Journal of Soil Science and Plant Nutrition*, **5**(1): 1–4. <https://doi.org/10.15580/gjsspn.2018.1.020718019>
- [7] Atedhor, G. O. and Orobator, P. O. (2012). Heavy Metals Contaminations in some selected Dumpsites in Benin City , Nigeria. *Ife Research Publications in Geography*, **11**(1): 97–110.
- [8] Oyeku, O. T. and Eludoyin, A. O. (2010). Heavy metal contamination of groundwater resources in a Nigerian urban settlement. *African Journal of Environmental Science and Technology*, **4**(4): 201–204.
- [9] Adegoke, O. S., Jeje, L. K., Durotoye, B., Adeleye, D. R. and Ebukanson, E. E. (1980). The geomorphology and aspects of sedimentology of coastal region of Western Nigeria. *J. Min. Geol.* **17**: 1980, pp. 217–223.
- [10] Okosun, E. A. 1970. A review of the Cretaceous stratigraphy of the Dahomey Embayment, West Africa. *Cretaceous Research*, **11**: 1990, pp. 17–27.
- [11] Olabode, S. O. (2006). Siliciclastic slope deposits from the Cretaceous Abeokuta Group, Dahomey(Benin) Basin, southwestern Nigeria. *Journal of Africa Earth Science*, **46**: 187–200.
- [12] Ogbe, F. A. G. (1970). Stratigraphy of strata exposed in the Ewekoro quarry, Western Nigeria. In: Dessauvagie, T. F. J., Whiteman, A.J. (ed) *African Geology*, University of Ibadan Press, Nigeria. 305–324
- [13] Durotoye, A. B. 1875. Quaternary sediments in Nigeria. In: Kogbe, C. A. (ed) *Geology of Nigeria* Elizabeth press, Lagos, 431–451.
- [14] Gebhardt, H., Adekeye, O. A. and Akande, S. O. (2010). Late Paleocene to initial Eocene thermalmaximum foraminifera biostratigraphy and paleoecology of the DahomeyBasin, southwestern Nigeria. *Gjabrbuch Der GeologischemBundesantalt*, **150**: 407–419.



- [15] Aizebeokhai, A. P. Oyeyemi, K. D. 2014. The use of the multiple array for geoelectrical resistivity and induced polarization imaging. *Journal of Applied Geophysics* **111**: 364-375.
- [16] Aizebeokhai, A. P., Oyeyemi K. D. and Kayode O. T. (2015). Assessment of soil petrophysical parameters using electrical resistivity tomography (ERT) and induced polarization techniques. *Research Journal of Applied Sciences* **10(9)**:479-485.
- [17] Oyeyemi, K. D., Aizebeokhai, A. P. and Oladunjoye, M. A.(2015). Integrated Geophysical and Geochemical investigation of saline water intrusion in a coastal alluvial terrain, Southwestern Nigeria. *International Journal of Applied Environmental Sciences* **10(4)**: 275– 1288.
- [18] Aizebeokhai, A. P., Oyeyemi, K. D. and Joel, E. L. (2016). A Groundwater potential assessment in a sedimentary terrain southwestern Nigeria. *Arabian Journal of Geoscience* **9**: 110–117.[doi.org/10.1007/s12517-016-2524-5](https://doi.org/10.1007/s12517-016-2524-5)
- [19] Aizebeokhai, A. P., Oyeyemi, K. D. and Joel, E. L. 2016. Electrical resistivity and induced polarization imaging for groundwater exploration. SEG International Exposition and Annual Meeting, Texas. 2487-2491
- [20] Oyeyemi, K. D. and Olofinnade, O. M. (2016). Geoelectrical –Geotechnical studies for nearsurface characterization, case history: Lagos, SW Nigeria. *Electronic Journal of Geotechnical Engineering***21(10)**: 3735–3750.
- [21] Aizebeokhai, A. P. and Oyeyemi, K. D. 2017. Geoelectrical characterization of basement aquifers: the case of Iberekodo, southwestern Nigeria. *Hydrogeology Journal* **26(2)**: 651–664[http://doi.org/10.1007/s10040-017-1679-9](https://doi.org/10.1007/s10040-017-1679-9)
- [22] Aizebeokhai, A. P., Oyeyemi, K. D., Noiki, F. R., Etete, B. I., Arere, A. U. E., Eyo, U. J. and Ogbuehi, V. C. (2017). Geoelectrical resistivity data sets for characterization and aquifer delineation in Iyesi, southwestern Nigeria. *Data in Brief* **15**:828–832 [http://doi:10.1016/j.dib.\(2017\).10.057](https://doi.org/10.1016/j.dib.(2017).10.057)
- [23] Oyeyemi, K. D., Aizebeokhai, A. P., Adagunodo, T. A., Olofinnade, O. M., Sanuade, A. O. and Olajo, A. A. (2016). Subsoil characterization using geoelectrical and geotechnical investigations: Implications for foundation studies. *International Journal of Civil Engineering and Technology***10(8)**:302-314.
- [24] Aizebeokhai, A. P., Okenwa, U. N., Oyeyemi, K. D., Kayode, O. T. and Adeyemi, G. A. 2017. Soil characterization using satellite remote sensing in southwestern Nigeria: Implications for precision agriculture. *IOP Conference Series: Earth and Environmental Science* **173 (012027)**: 1–7
- [25] Adagunodo, T. A., Akinloye, M. K., Sunmonu, L. A., Aizebeokhai, A. P., Oyeyemi, K. D. and Abodunrin, F. O.( 2018). Groundwater exploration in Aaba residential area of Akure, Nigeria. *Frontiers in Earth Science*, **6(66)**: 1-12. [http://doi.10.3389/feart.2018.00066](https://doi.org/10.3389/feart.2018.00066)
- [26] Oyeyemi, K. D., Aizebeokhai, A. P., Sanuade, O. A., Ndambuki, J. M., Olofinnade, O. M., Olajo, A. A. and Adagunodo T. A. (2018). The use of geological-based geophysical surveys for groundwater distribution in crystalline basement terrain, SW Nigeria. *IOP Conference Series: Earth and Environmental Science*. **173**: (012029) 1-7
- [27] Oyeyemi, K. D., Aizebeokhai, A. P., Ndambuki, J. M., Sanuade, O. A., Olofinnade, O. M. Olajo, A. A., Adagunodo, T. A. and Adeyemi, G. A. (2018). Estimation of aquifer hydraulic parameters from surficial geophysical methods: a case study of Ota, Southwestern Nigeria. *Earth and Environmental Science*. **173 (012029)**: 1-7.
- [28] Aizebeokhai, A. P., Oni, A. A., Oyeyemi, K. D. and Ogungbade, O. (2018). Electrical resistivity imaging (ERI) data for characterizing crystalline basement structures in Abeokuta, Southwestern Nigeria. *Data in Brief*, **19**: 2393-2397.
- [29] Sanuade, O. A., Oyeyemi, K. D., Amosun, J. O., Fatoba, J. O. and Hammed, O. S. (2018). Prediction of transmissivity of aquifer from geoelectrical data using neural network. *Earth and Environmental Science*. **173 (012025)**: 1-7.

- [30] Adagunodo, T. A., Sunmonu, L. A., Olagoke, P. O., Hammed, O. S., Oyeyemi, K. D., and Kayode, O. T. (2018). Site characterization of Ayetoro housing scheme, Oyo, Nigeria. *Earth and Environmental Science*. **173 (012031)**: 1-7.
- [31] Loke, M. H. and Barker, R. D. Rapid least-squares inversion of apparent resistivity pseudo sections by a quasi-Newton method. *Geophysical Prospecting*, **44**: 1996, pp. 131–152.